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TITLE:

**FULLY ACTIVATED
BICOMPONENT WEB WITH
ABSORBENTS**

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FULLY ACTIVATED BICOMPONENT WEB WITH ABSORBENTS

BACKGROUND OF THE INVENTION

This invention relates to nonwoven web composites having thermoplastic bicomponent continuous filaments with a very high loading of absorbents.

5 Bicomponent nonwoven filaments are known in the art generally as thermoplastic filaments which employ at least two different polymers combined together in a heterogeneous fashion. Instead of being homogeneously blended, two polymers may, for instance, be combined in a side-by-side configuration, so that a first side of a filament is composed of a first polymer "A" and a second side of the filament is composed of a second polymer "B." Alternatively, the polymers may be combined in a sheath-core configuration, so that an outer sheath layer of a filament is composed of a first polymer "A," and the inner core is composed of a second polymer "B." Other heterogeneous configurations are also possible.

15 Bicomponent filaments offer a combination of desired properties. For instance, certain polypropylene resins yield filaments which are strong but not particularly soft. Certain polyethylene resins yield filaments which are soft but not particularly strong. By combining both resins together in the form of bicomponent nonwoven filaments, a hybrid combination of strength and softness can be achieved.

20 Bicomponent filaments have been disclosed in combination with carbon particles, zeolites, ion exchange resins, carbon fibers, sterilizing fibers, and/or gas adsorbing fibers for use in specialized filters. U.S. Patent 5,670,044, issued to Ogata

et al., discloses the use of bicomponent meltblown filaments in these combinations, for use in cylindrical filters. In that case, the bicomponent filaments contain high and low melting polymers. The filaments of the filter are stacked and bonded together by melting only the lower melting component. U.S. Patent 4,902,559, issued to Escheway et al., discloses mixing substantially continuous thermoplastic filaments with absorbents, including superabsorbents, before the filaments are deposited on the forming wire.

Pulp fibers have been employed in certain absorbent applications to enhance the absorbency. U.S. Patent 4,530,353, issued to Lauritzen, discloses pulp fibers in combination with staple length bicomponent fibers used in the manufacture of absorbent bandages. In that case, the fibers also contain high and low melting polymers. The staple length fibers are bonded together by melting only the lower melting component.

There is a need or desire for an absorbent nonwoven web composite which exhibits good softness and strength with a high degree of absorbency. There is a further need to achieve a high degree of absorbent particle loading in a nonwoven web to economically and efficiently make highly absorbent webs for personal care absorbent articles. This need exists for diapers, training pants, wipes, and other personal care absorbent articles where comfort, strength, and absorbent performance are all important.

SUMMARY OF THE INVENTION

The present invention is directed to an improved absorbent nonwoven web composite suitable for use in personal care absorbent articles, and is intended to encompass such personal care absorbent articles constructed using the improved composite. The absorbent nonwoven web composite includes a web of substantially continuous length bicomponent thermoplastic nonwoven filaments having a high weight percent quantity of absorbents such as pulp fibers or superabsorbents, or both, secured within the continuous filament web. A method of obtaining the high loading by bonding the absorbents to fully activated, or liquid, portions of the thermoplastic bicomponent, and densifying the fully activated web are further disclosed.

The substantially continuous bicomponent filaments, especially when of the sheath-core variety, provide an effective amount of liquid outer core area during formation of the web for surface bonding to the absorbents and a more substantial frame work for the resultant web than would be the case with staple thermoplastic filaments alone. Further, because they remain uncut, the substantially continuous bicomponent filaments are believed to provide better distribution of liquids than staple length filaments, which are chopped into relatively short lengths. Desirably, in certain aspects or embodiments, the polymers in the bicomponent filaments are selected so that at least one of the polymers provides strength and durability, and at least one of the polymers provides softness, to the nonwoven web.

More desirably, the sheath will have a lower melting than the polymer of the core, allowing the sheath to reach a state of complete, or full, activation, i.e.,

become liquid, without necessarily flowing, during processing of the web in order to maximally wet the absorbents and bind them to the web with hardened flow joints when the web is cooled to again set, or recrystallize, the sheath of the bicomponent fiber. During the time of full activation, the web is further densified, such as by running through a nip between two calender, or compression, rollers to further ensure a greater contact between the activated sheath and the absorbent particles and provide a web which is suitably compressed and thin for use in personal care products. The absorbents, such as pulp fibers, superabsorbent particles, or the like, are better contained within the matrix of continuous filaments having strength and durability and thus may constitute up to about 97% by weight of the absorbent nonwoven web composite through practice of the present invention.

It is thus a feature and advantage of the invention to provide an improved absorbent nonwoven web composite capable of containing high absorbent loadings within a continuous filament matrix as suitable for use as a primary liquid retention mechanism in a personal care product.

DEFINITIONS

“Air-laying” is a well-known process by which a fibrous nonwoven layer can be formed. In the air-laying process, bundles of small fibers having typical lengths ranging from about 3 to about 19 millimeters (mm) are separated and entrained in an air supply and then deposited onto a moving forming screen, usually with the assistance of a vacuum supply. The randomly deposited fibers then are bonded to one another using, for example, hot air or a spray adhesive. Air-laying is

taught in, for example, U.S. Patent 4,640,810 to Laursen et al. Air-laying may include coform deposition which is a known variant wherein pulp or other absorbent fibers are deposited in the same air stream onto the forming screen. The screen may also be referred to herein as a forming wire. Air-laying may include multibank deposition which is known in the art to be a technique whereby multiple spray heads for the various fibers or components are located in series along the machine direction of the forming wire to serially deposit the same or different materials in layers onto the forming wire.

The term "bicomponent filaments" or "bicomponent fibers" refers to fibers which have been formed from at least two polymers extruded from at least two separate extruders but spun together to form one fiber and may also be referred to herein as "conjugate" or "multicomponent" fibers. "Bicomponent" is not meant to be limiting to only two constituent polymers unless otherwise specifically indicated. The polymers are arranged in substantially constantly positioned distinct zones across the cross-section of the bicomponent fibers and extend continuously along the length of the bicomponent fibers. The configuration of such a bicomponent fiber may be, for example, a sheath-core arrangement wherein one polymer is surrounded by another, or may be a side-by-side, A/B, arrangement or an A/B/A, side-by-side(-by-side), arrangement. Bicomponent fibers are generally taught in U.S. Patent 5,108,820 to Kaneko et al., U.S. Patent 5,336,552 to Strack et al., and U.S. Patent 5,382,400 to Pike et al. For two component fibers, the polymers may be present in ratios of 75/25, 50/50, 25/75 or any other desired ratios. Conventional additives, such as pigments

and surfactants, may be incorporated into one or both polymer streams, or applied to the filament surfaces.

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The term "microfibers" means small diameter fibers having an average diameter not greater than about 75 microns, for example, having an average diameter of from about 1 micron to about 50 microns, or more particularly, having an average diameter of from about 1 micron to about 30 microns. Another frequently used expression of fiber diameter is denier, which is defined as grams per 9000 meters of a fiber. For a fiber having circular cross-section, denier may be calculated as fiber diameter in microns squared, multiplied by the density in grams/cc, multiplied by 0.00707. A lower denier indicates a finer fiber and a higher denier indicates a thicker or heavier fiber. For example, the diameter of a polypropylene fiber given as 15 microns may be converted to denier by squaring, multiplying the result by .89 g/cc (an assumed polypropylene density for this example) and multiplying by .00707. Thus, a 15 micron polypropylene fiber has a denier of about 1.42 ($15^2 \times 0.89 \times .00707 = 1.415$). Outside the United States the unit of measurement is more commonly the "tex," which is defined as the grams per kilometer of fiber. Tex may be calculated as denier/9.

The term "nonwoven fabric" or "nonwoven web" means a web having a structure of individual fibers or threads which are interlaid, but not in a regular or identifiable manner as in a knitted fabric. Nonwoven fabrics or webs have been formed from many processes such as, for example, meltblowing processes, spunbonding processes, air-laying processes, and bonded carded web processes. The

basis weight of nonwoven fabrics is usually expressed in ounces of material per square yard (osy) or grams per square meter (gsm) and the fiber diameters are usually expressed in microns. (Note that to convert from osy to gsm, multiply osy by 33.91).

The term “meltblown fibers” means fibers formed by extruding a molten thermoplastic material through a plurality of fine, usually circular, die capillaries as molten threads or filaments into converging high velocity heated gas (e.g., air) streams which attenuate the filaments of molten thermoplastic material to reduce their diameter, which may be microfiber diameter. Thereafter, the meltblown fibers are carried by the high velocity gas stream and are deposited on a collecting surface to form a web of randomly dispersed meltblown fibers. Such a process is disclosed for example, in U.S. Patent 3,849,241 to Butin et al. Meltblown fibers are microfibers which may be continuous or discontinuous, are generally smaller than 10 microns in diameter, and are generally self bonding when deposited onto a collecting surface.

The term “pulp fibers” refers to fibers from natural sources such as woody and non-woody plants. Woody plants include, for example, deciduous and coniferous trees. Non-woody plants include, for instance, cotton, flax, esparto grass, milkweed, straw, jute, hemp, and bagasse.

The term "polymer" generally includes without limitation homopolymers, copolymers (including, for example, block, graft, random and alternating copolymers), terpolymers, etc., and blends and modifications thereof. Furthermore, unless otherwise specifically limited, the term "polymer" shall include

all possible geometrical configurations of the material. These configurations include, but are not limited to isotactic, syndiotactic and atactic symmetries.

“Personal care product” or “personal care absorbent article” means diapers, wipes, training pants, absorbent underpants, adult incontinence products, 5 feminine hygiene products, wound care items like bandages, and other like articles.

The term “spunbond fibers” refers to small diameter fibers which are formed by extruding molten thermoplastic material as filaments from a plurality of fine capillaries of a spinneret having a circular or other configuration, with the diameter of the extruded filaments then being rapidly reduced as by, for example, in U.S. Patent 4,340,563 to Appel et al., and U.S. Patent 3,692,618 to Dorschner et al., 10 U.S. Patent 3,802,817 to Matsuki et al., U.S. Patent 3,338,992 and 3,341,394 to Kinney, U.S. Patent 3,502,763 to Hartman, U.S. Patent 3,502,538 to Petersen, and U.S. Patent 3,542,615 to Dobo et al. Spunbond fibers are quenched and generally not tacky when they are deposited onto a collecting surface. Spunbond fibers are generally continuous and usually have average diameters larger than meltblown 15 fibers, and more particularly, generally between about 10 and 30 microns.

The term “substantially continuous filaments” or “substantially continuous fibers” refers to filaments or fibers prepared by extrusion from a spinneret, including without limitation spunbond and meltblown fibers, which are not cut from 20 their original length prior to being formed into a nonwoven web or fabric. Substantially continuous filaments or fibers may have average lengths ranging from greater than about 15 cm to more than one meter, and up to the length of the

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nonwoven web or fabric being formed. The definition of "substantially continuous filaments" (or fibers) includes those filaments or fibers which are not cut prior to being formed into a nonwoven web or fabric, but which are later cut when the nonwoven web or fabric is cut.

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The term "superabsorbent material" refers to a water swellable, water-insoluble organic or inorganic material capable, under the most favorable conditions, of absorbing at least about 20 times its weight, preferably at least about 30 times its weight in an aqueous solution containing 0.9% by weight sodium chloride.

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The term "staple fibers" means fibers which are natural or cut from a manufactured filament prior to forming into a web, and which have an average length ranging from about 0.1-15 cm, more commonly about 0.2-7 cm.

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The term "through-air bonding" or "TAB" means a process of bonding a nonwoven, for example, a bicomponent fiber web in which air which is sufficiently hot to melt one of the polymers of which the fibers of the web are made is forced through the web. The air velocity is often between 100 and 500 feet per minute and the dwell time may be as long as 20 seconds. The melting and resolidification of the polymer provides the bonding. Since TAB requires the melting of at least one component to accomplish bonding, it is generally restricted to webs with two components such as bicomponent fiber webs or webs containing an adhesive fiber or powder.

Words of degree, such as "about," "substantially," and the like are used herein in the sense of "at, or nearly at, when given the manufacturing and material

tolerances inherent in the stated circumstances" and are used to prevent the unscrupulous infringer from unfairly taking advantage of the invention disclosure where exact or absolute figures are stated as an aid to understanding the invention.

5 "Online" refers to a continuous process for forming an integral web on a single forming line, as opposed to a material constructed from multiple webs formed on multiple lines and then put together as component pieces.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Fig. 1 is a schematic illustration of an exemplary embodiment of an apparatus and method for making a fully activated densified web according to the present invention.

Fig. 2 is a schematic view of a personal care absorbent article having a cutaway of the body side liner to illustrate utilization of a fully activated densified web.

15 Fig. 3 is a schematic illustration of a second exemplary embodiment of an apparatus and method for making a fully activated densified web according to the present invention.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

20 The present invention is directed to an absorbent composite nonwoven web composite including substantially continuous bicomponent thermoplastic filaments and absorbents strongly adhered to the filaments. Desirably, the absorbent nonwoven web composite contains up to about 97% by weight absorbent and about

down to 3% by weight of substantially continuous, sheath-core, bicomponent, thermoplastic filaments.

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The substantially continuous bicomponent thermoplastic filaments may have any of the bicomponent configurations described above and are desirably in the 15-25 micron diameter range. Desirably, the filaments have either of an A/B or A/B/A side-by-side configuration, or a sheath-core configuration. More desirably, a sheath-core configuration is used to provide the maximum amount of lower melting point sheath polymer material with which to contact, wet, and secure, the absorbent particles or fibers also contained in the web. The substantially continuous filaments are most typically spunbond filaments, although some meltblown microfibers may be added to the web, for various reasons, as further discussed below. Alternatively, bicomponent meltblown filaments may be used in some embodiments of the invention. Other processes for forming substantially continuous filaments may also be employed. The filaments may further be crimped, using techniques available to 15 persons skilled in the art.

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The substantially continuous bicomponent filaments contain at least two thermoplastic polymers. The substantially continuous bicomponent filaments contain a first polymer which melts before the second polymer. For ease of explanation the first polymer will be referred to hereinafter as the sheath polymer, and the second polymer will be referred to as the core polymer, although it will be understood that the filaments need not be sheath-core configuration according to some aspects of the 20 present invention. The sheath polymer may contribute one or more desirable

properties beyond its low melting point and wettability of the absorbents in its liquid state. For example, polar functional groups may be added to the sheath polymer to aid in the attachment of the absorbent fibers thereto. Polymers may also be provided in the sheath which have high wettability for liquid water distribution within the web.

5 Also, the core polymer may contribute one or more additional desirable properties beyond its strength and durability. The bicomponent filaments may include more than two distinct polymers, with each polymer contributing unique properties. For example, the bicomponent filaments may include a distinct polymer blend having desirable properties, adjacent to another distinct polymer or polymer blend. Additives, such as pigments and hydrophilic modifiers, may be incorporated into one or both polymers, or applied to the filament surfaces.

Examples of core polymer components suitable for use in the present invention may include, without limitation: polypropylene, polybutylene terephthalate, polyethylene terephthalate, or Nylon. Other polymers may include, without limitation: polypropylene homopolymers, polypropylene copolymers containing up to about 10% ethylene or another C₄-C₂₀ alpha-olefin comonomer, high density polyethylenes, linear low density polyethylenes in which the alpha-olefin comonomer content is less than about 10% by weight, polyamides, polyesters, polycarbonates, polytetrafluoroethylenes, and other high tensile materials. Generally, a first polymer can be said to contribute durability to bicomponent filaments when a nonwoven web made from bicomponent filaments containing a first polymer and a second polymer withstands a tensile load which is at least about 10% greater, and preferably at least

about 30% greater, than a similar nonwoven web made from similar filaments containing the second polymer alone.

Examples of sheath polymer components which contribute a low melting point and good wetting of the absorbent particles within the web may include, 5 without limitation: polyethylene, polypropylene, fluropolyolefins or polybutylenes. Other polymers may include, without limitation: high pressure (branched) low density polyethylenes, linear low density polyethylenes in which the alpha-olefin comonomer content is more than about 10% by weight, copolymers of ethylene with at least one vinyl monomer (for example, ethylene vinyl acetate), copolymers of ethylene with unsaturated aliphatic carboxylic acids (including ester derivatives thereof) and copolymers of any two alpha-olefins having 2-20 carbon atoms wherein the content of each of the two comonomers exceeds 10% by weight of the copolymer (including, for instance, ethylene-propylene rubbers). Also included are thermoplastic polyurethanes, A-B and A-B-A' block copolymers where A and A' are thermoplastic 10 end blocks and B is an elastomeric block.

Examples of polymers which contribute wettability to a thermoplastic nonwoven web include without limitation polyamides, polyvinyl acetates, saponified polyvinyl acetates, saponified ethylene vinyl acetates, and other hydrophilic materials. A polymer generally contributes to the wettability of bicomponent filaments if a 15 droplet of water positioned on a nonwoven web made from bicomponent filaments containing first and second polymers has a contact angle which is a) less than 90 degrees measured using ASTM D724-89, and b) less than the contact angle of a

similar nonwoven web made from similar filaments containing only the first polymer. When used as an outer layer in a sheath-core bicomponent filament web, the hydrophilic polymer imparts surface wettability to the entire web.

The substantially continuous thermoplastic bicomponent nonwoven filaments may be combined with pulp fibers using processes well known in the art. For example, a coform process may be employed, in which at least one meltblown diehead is arranged near a chute through which other materials are added while the web is forming. Coform processes are described in U.S. Patent 4,818,464 to Lau and 4,100,324 to Anderson et al.

The pulp fibers may be any high-average fiber length pulp, low-average fiber length pulp, or mixtures of the same. Preferred pulp fibers include cellulose fibers. The term "high average fiber length pulp" refers to pulp that contains a relatively small amount of short fibers and non-fiber particles. High fiber length pulps typically have an average fiber length greater than about 1.5 mm, preferably about 1.5-6 mm. Sources generally include non-secondary (virgin) fibers as well as secondary fiber pulp which has been screened. The term "low average fiber length pulp" refers to pulp that contains a significant amount of short fibers and non-fiber particles.

Examples of high average fiber length wood pulps include those available from the U.S. Alliance Coosa Pines Corporation under the trade designations Longlac 19, Coosa River 56, and Coosa River 57. The low average fiber length pulps may include certain virgin hardwood pulp and secondary (i.e., recycled)

fiber pulp from sources including newsprint, reclaimed paperboard, and office waste. Mixtures of high average fiber length and low average fiber length pulps may contain a predominance of low average fiber length pulps. For example, mixtures may contain more than about 50% by weight low-average fiber length pulp and less than 5 about 50% by weight high-average fiber length pulp. One exemplary mixture contains about 75% by weight low-average fiber length pulp and about 25% by weight high-average fiber length pulp.

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The pulp fibers may be unrefined or may be beaten to various degrees of refinement. Crosslinking agents and/or hydrating agents may also be added to the pulp mixture. Debonding agents may be added to reduce the degree of hydrogen bonding if a very open or loose nonwoven pulp fiber web is desired. One exemplary debonding agent is available from the Quaker Oats Chemical Company, Conshohocken, Pennsylvania, under the trade designation Quaker 2008. The addition of certain debonding agents in the amount of, for example, 1-4% by weight of the pulp, may reduce the measured static and dynamic coefficients of friction and improve the abrasion resistance of the thermoplastic continuous polymer filaments. The debonding agents act as lubricants or friction reducers. Debonded pulp fibers are commercially available from Weyerhaeuser Corp. under the designation NB 405.

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In another highly advantageous embodiment, a quantity of a superabsorbent material is combined with the substantially continuous bicomponent thermoplastic polymer filaments, to improve the absorbency of the absorbent nonwoven web composite, with or without pulp fibers. The term "superabsorbent"

or "superabsorbent material" refers to a water-swellable, water-insoluble organic or inorganic material capable, under the most favorable conditions, of absorbing at least about 10 times its weight and, more desirably, at least about 30 times its weight in an aqueous solution containing 0.9 weight percent sodium chloride at room temperature and pressure.

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The superabsorbent materials can be natural, synthetic and modified natural polymers and materials. In addition, the superabsorbent materials can be inorganic materials, such as silica gels, or organic compounds such as cross-linked polymers. The term "cross-linked" refers to any means for effectively rendering normally water-soluble materials substantially water insoluble but swellable. Such means can include, for example, physical entanglement, crystalline domains, covalent bonds, ionic complexes and associations, hydrophilic associations, such as hydrogen bonding, and hydrophobic associations or Van der Waals forces.

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Examples of synthetic superabsorbent material polymers include the alkali metal and ammonium salts of poly(acrylic acid) and poly(methacrylic acid), poly(acrylamides), poly(vinyl ethers), maleic anhydride copolymers with vinyl ethers and alpha-olefins, poly(vinyl pyrrolidone), poly(vinylmorpholinone), poly(vinyl alcohol), and mixtures and copolymers thereof. Further superabsorbent materials include natural and modified natural polymers, such as hydrolyzed acrylonitrile-grafted starch, acrylic acid grafted starch, methyl cellulose, chitosan, carboxymethyl cellulose, hydroxypropyl cellulose, and the natural gums, such as alginates, xanthum gum, locust bean gum and the like. Mixtures of natural and wholly or partially

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synthetic superabsorbent polymers can also be useful in the present invention. Other suitable absorbent gelling materials are disclosed by Assarsson et al. in U.S. Patent 3,901,236 issued August 26, 1975. Processes for preparing synthetic absorbent gelling polymers are disclosed in U.S. Patent 4,076,633 issued February 28, 1978 to 5 Masuda et al. and U.S. Patent 4,286,082 issued August 25, 1981 to Tsubakimoto et al.

Superabsorbent materials may be xerogels which form hydrogels when wetted. The term "hydrogel," however, has commonly been used to also refer to both the wetted and unwetted forms of the superabsorbent polymer material. The superabsorbent materials can be in many forms such as flakes, powders, particulates, fibers, continuous fibers, networks, solution spun filaments and webs. The particles can be of any desired shape, for example, spiral or semi-spiral, cubic, rod-like, polyhedral, etc. Needles, flakes, fibers, and combinations may also be used.

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When used, the superabsorbent material may be present within the absorbent nonwoven composite in an amount from about 5 to about 90 weight percent based on total weight of the absorbent nonwoven composite. Preferably, the superabsorbent constitutes about 10-60% by weight of the absorbent nonwoven web composite, more preferably about 20-50% by weight. Superabsorbents are generally available in particle sizes ranging from about 20 to about 1000 microns. Examples of commercially available particulate superabsorbents include SANWET® IM 3900 and SANWET® IM-5000P, available from Hoescht Celanese located in Portsmouth, Virginia, DRYTECH® 2035LD available from Dow Chemical Co. located in Midland, Michigan, and FAVOR® 880, available from Stockhausen, located in Greensborough,

North Carolina. An example of a fibrous superabsorbent is OASIS® 101, available from Technical Absorbents, located in Grimsby, United Kingdom.

The superabsorbents may be added using the same techniques described for combining the pulp fibers and continuous bicomponent nonwoven filaments. For instance, the superabsorbent can be added with the pulp into the forming stream for the bicomponent filaments as they are being extruded onto a conveyor to form a nonwoven web, or at a later point in the forming stream, separate from the pulp.

Various improvements and alternative embodiments are also considered to be within the scope of the invention. In one embodiment, the continuous bicomponent thermoplastic filaments are combined with other thermoplastic filaments in addition to the absorbents. For instance, the continuous bicomponent thermoplastic filaments may include a mixture of bicomponent spunbond filaments and higher melting point meltblown filaments. In this embodiment, the meltblown filaments may be effective in creating or maintaining fluid channels within the web beyond that inherent in using the spunbond filaments.

In another embodiment, the continuous bicomponent filaments may be spunbond and mixed with meltblown fibers which have a relatively low melting point. The composite web may thus be formed by combining three or more streams of bicomponent spunbond filaments, lower melting meltblown filaments and pulp fibers. The meltblown filaments may still be hot and tacky when the pulp fibers are introduced, and may fuse with the pulp fibers to help consolidate the structure. Meltblown microfibers, which typically have diameters much smaller than spunbond

fibers, may in effect serve as an additional binder or adhesive for the pulp fibers. The meltblown fibers are desirably in the 2-10 micron diameter range.

In another embodiment, side-by-side bicomponent filaments having the ability to crimp are used as thermoplastic filaments. The substantially continuous crimped bicomponent filaments may be in the form of meltblown microfibers, or be spunbond filaments. Crimped bicomponent filaments can be used with or without other thermoplastic filaments in a nonwoven web to provide enhanced bulk and lower web density.

Fig. 1 is a schematic diagram illustrating methods and apparatus of this invention for producing fully activated bicomponent webs with high absorbent loading, the ability to maintain density after bonding, increased stiffness and good mechanical properties, low polymer levels and the concomitant ability to maintain wettability due to low polymer content.

As shown in Fig. 1, two polymers A and B are spunbond with known thermoplastic fiber spinning apparatus 21 to form bicomponent side-by-side, or more desirably, sheath-core, morphology fibers 23. The fibers may, for example, be a PE/PBT/PE side-by-side in A/B/A morphology, or a PE/PP sheath-core morphology, in the range of 15 to 25 microns. The fibers 23 are then traversed through a fiber distribution unit (FDU) 25. According to one embodiment of the present invention, the absorbent components such as pulp fibers, superabsorbents, or both, may be added to the FDU 25 by a separate entrainment as at 24, aiding in the efficient distribution of the absorbents within the thermoplastic fiber mass over that of typical random air-

laying processes of separate fiber and absorbent streams applied directly to a forming wire 27. Dependent upon the personal care product application, the amount of absorbent may be between about 3 weight percent and about 97 weight percent pulp fibers with the remainder being thermoplastic fibers, and desirably between about 35 weight percent and about 95 weight percent pulp fibers, with between about 5 weight percent to 65 weight percent thermoplastic fiber for absorbent core retention applications. In some applications the amount of absorbent will desirably be between about 50 weight percent and about 95 weight percent pulp fibers and with between about 5 weight percent to 65 weight percent thermoplastic fiber for absorbent core retention or distribution applications. In some applications where high liquid retention is especially desired in the absorbent core, the amount of superabsorbent will comprise between about 5 weight percent and about 90 weight percent of total mass, in some cases desirably between about 10 weight percent and about 60 weight percent of total mass, and in some cases more desirably between about 20 weight percent and about 50 weight percent of total mass.

The thermoplastic fibers 23 are left in a substantially continuous state and are deposited on a moving forming wire 27. Deposition of the fibers is aided by an under-wire vacuum supplied by a negative air pressure unit, or below wire exhaust, 29. Additional thermoplastic fibers, e.g. meltblown fibers, may be added to the wire 27, as at depositing head 28, or entrained into the FDU 25, as indicated by phantom line 30. The meltblown fibers may be, e.g., homofilament or bicomponent, desirably

in the diameter range of 2 to 10 microns, and may be of higher or lower melting point than the sheath polymer of the spunbond bicomponent fibers, as discussed above.

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The fibers 23 are then heated to fully activate the sheath polymer of the bicomponent fibers to a liquid state by traversal under one of a hot air knife (HAK) or hot air diffuser, as indicated at 33, and will be appreciated to be used in the alternative under normal circumstances. A conventional hot air knife includes a mandrel with a slot that blows a jet of hot air onto the nonwoven web surface. Such hot air knives are taught, for example, by U.S. Patent 5,707,468 to Arnold, et al. A hot air diffuser is an alternative which operates in a similar manner but with lower air flow over a greater surface area and thus generally uses correspondingly lower air temperatures to maintain the integrity of the web.

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If necessary or desired, the web 37 is then transported to a through air bonding (TAB) unit 39 to fully activate the web 37 bringing the sheath polymer of the bicomponent fibers to a liquid state where it can flow onto, or wet, the absorbent components of the web. It will be appreciated that the TAB unit 39 may be used in the alternative as the sole heat activation means for the web and may offer a better range of sheath polymer activation control than the hot air knife or diffuser 33. Care should be taken to minimize flow of the melted sheath polymer beyond that needed to wet the absorbents. Desirably the web is subjected to between about 160°F and about 300°F for a period of time between about 0.5 to about 20 seconds to achieve full activation of polymer component A of the multicomponent meltblown filaments. More preferably, the time period is between about 1 to about 10 seconds and most

preferably about 4-7 seconds. However, the type of polymer and the oven temperature will govern the actual time the need to melt or soften the sheath polymer component.

While the web 37 is still fully activated it is then densified, such as by compression through a nip formed by two calender rolls 41. Densification is desirable in a preferred embodiment to between about 0.05 g/cc and 0.50 g/cc, and more desirably to between about 0.05 g/cc and 0.20 g/cc for use in some personal product applications. The calender rolls 41 may, but need not, provide point bonding of the web and may be heated to maintain the full activation of the web during densification. Alternatively, the calendar rolls 41 may be cooled to provide a means for removing heat from the fully activated web in order to solidify the flow of the sheath polymer which has wetted around the absorbent material, thereby creating hardened flow joints securing the absorbent material within the thermoplastic matrix of the web. Alternatively, the densified web 40 is fixed to form the hardened flow joints and prevent further bonding or collapse of the web by a forced air cooling unit 44 pulling ambient air through the web, or the like. The stabilized and densified web 40 can then be collected on a winding roll 43 or the like for later use.

The absorbent nonwoven composite of the invention thus provides a high loading of absorbent particles in a densified web of stable and desirable physical properties. The web can be used in a wide variety of absorbent products including, in particular, personal care absorbent articles. Personal care absorbent articles include diapers, training pants, swim wear, absorbent underpants, baby wipes, adult

incontinence products, feminine hygiene products, and the like. For example, referencing Fig. 2, a diaper 51 may have a cover sheet 57 serving as the exterior layer of the article facing away from a wearer's skin; a top sheet 53 serving as the interior layer of the article facing towards a wearer's skin; and a primary liquid retention layer 55 therebetween as constructed from a web of the present invention. The absorbent nonwoven composite can also be used in absorbent medical products, including without limitation underpads, bandages, absorbent drapes, and medical wipes which contain alcohol and/or other disinfectants, and household wipes and mops of the wet or the dry variety.

Fig. 3 schematically shows a process and apparatus for forming a coform nonwoven web of the present invention using two meltblown dies which is generally represented by reference numeral 100. As is noted above, a process of the present invention can be practiced using a single meltblown die. For the present explanation, an exemplary process will be described in terms of using two meltblown dies. The process line 100 is arranged to produce bicomponent substantially continuous filaments, but it should be understood that the present invention comprehends nonwoven webs made with multicomponent filaments having more than two components. For example, the web of the present invention can be made with filaments having three, four or more components. In forming the absorbent nonwoven composite structure of the present invention, pellets or chips, etc. (not shown) of a thermoplastic polymer are introduced into pellet hoppers 112, 112', 113 and 113' of extruders 114, 114', 115 and 115'.

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The extruders 114, 114', 115 and 115' each have an extrusion screw (not shown) which is driven by a conventional drive motor (not shown). As the polymer advances through the extruders 114, 114', 115 and 115', due to rotation of the extrusion screw by the drive motor, it is progressively heated to a molten state. Heating of the thermoplastic polymer to the molten state may be accomplished in a plurality of discrete steps with the temperature of the thermoplastic polymer being gradually elevated as it advances through discrete heating zones of the extruders 114, 114', 115 and 115' toward two meltblowing dies 116 and 118, respectively. The meltblowing dies 116 and 118 may be yet another heating zone where the temperature of the thermoplastic resin is maintained at an elevated level for extrusion.

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As shown in Fig. 3, each meltblown die is configured so that at least two streams of attenuating fluid per die converge to form a single stream of fluid which entrains and attenuates molten threads 120, as the threads 120 exit small holes or orifices 124 in each meltblowing die. The molten threads 120 are attenuated into filaments or, depending upon the degree of attenuation, microfibers, of a small diameter which is usually less than the diameter of the orifices 124. Thus, each meltblowing die 116 and 118 has a corresponding single stream of fluid 126 and 128, containing entrained and attenuated polymer filaments. The fluid streams 126 and 128 containing polymer filaments are aligned to converge at an impingement zone 130, and form a converged fluid stream 132, which contains the attenuated multicomponent filaments.

One or more types of a second material 136, which can include fibers and/or particulates are added to the two streams 126 and 128 of multicomponent filaments or microfibers 120 at the impingement zone 130. Introduction of second material fibers or particulates 136 into the two streams 126 and 128 of multicomponent filaments is designed to produce a distribution of the second material 136 within the combined streams 126 and 128 of multicomponent filaments. This may be accomplished by merging a secondary gas stream 134 containing the second fibers or particles 136 between the two streams 126 and 128 of the multicomponent filaments 124 so that all three gas streams converge in a controlled manner at the impingement zone 130.

Apparatus 140 generates the second gas stream 134 containing the absorbent material 136. The apparatus for accomplishing the merger of the fluid streams 126, 128 and 134 may include a conventional picker roll or particulate injection system. In a conventional picker roll arrangement (not shown), a plurality of teeth are adapted to separate a mat or batt of an absorbent fibrous material into the individual absorbent fibers. The sheets or mats of the fibrous material are fed to the picker roll by a roller arrangement and the teeth of the picker roll separate the mat of fibrous material into separate second material staple fibers 136 which are conveyed toward the streams of thermoplastic multicomponent polymer filaments 126 and 128 through a nozzle 144, and optionally a chute 146. Generally a gas, for example, air, is supplied to the picker via a gas duct. The gas is supplied in sufficient quantity to serve as a medium for conveying the second fibers 136 through the nozzle 144. The

gas may be supplied by any conventional arrangement such as, for example, an air blower (not shown). It is contemplated that additives and/or other materials may be added, to or entrained in, the gas stream to treat the second fibers.

The second material 136 generally maintains its velocity in both magnitude and direction. An example of a conventional picker can be found in, for example, U.S. Patent 4,100,324 to Anderson, et al., hereby incorporated by reference in its entirety, which discusses the picker in more detail.

The width of the nozzle 144 should be aligned in a direction generally parallel to the width of the meltblowing dies 116 and 118. Desirably, the width of the nozzle 144 should be about the same as the width of the meltblowing dies 116 and 118. The width of the optional chute 146 is likewise about the same as the width of the meltblowing dies 116 and 118. Usually, the width of the nozzle 144 should not exceed the width of the sheets or mats that are being fed to the picker roll. Generally speaking, it is desirable for the length of the nozzle 144 to be as short as equipment design will allow.

The apparatus 140 may also be a conventional particulate injection system to form an absorbent nonwoven web or coform composite structure 154 containing various absorbent particulates. In addition, a combination of both absorbent particulates and absorbent fibers could be added to the thermoplastic multicomponent polymer filaments prior to formation of the absorbent nonwoven web 154, if both a conventional particulate injection system and a conventional picker are used.

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Fig. 3 further illustrates that the secondary fluid stream 134 carrying the second material 136 is directed between the fluid streams 126 and 128 of thermoplastic multicomponent polymer filaments so that the streams contact at the impingement zone 130. Apparatus 140 is shown to be located between the meltblown dies 116 and 118, however, it should be noted that the apparatus 140 could be located below the meltblown dies 116 and 118 such that the absorbent material could be injected into the converged stream 132, at or below the impingement zone 130 of fluid streams 126 and 128. The velocity of the secondary fluid stream 134 is usually adjusted so that it is less than the velocity of each stream 126 and 128 of thermoplastic multicomponent polymer filament when the streams contact at the impingement zone 130, which results in better homogenous mixing of the second material with the multicomponent filaments. However, it should be noted that the velocity of the fluid stream 134 can be greater than the velocity of streams 126 or 128, or the converged stream 132.

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Generally, for increased production rates, the fluid streams which entrain and attenuate the multicomponent thermoplastic polymer fibers 120 should have a comparatively high initial average velocity, for example, from about 200 feet to over 1,000 feet per second. However, the velocity of those fluid streams 126, 128 decreases rapidly as they expand and become separated from the meltblown die. Thus, the velocity of those fluid streams 126, 128 at the impingement zone may be controlled by adjusting the distance between the meltblown die and the impingement zone 130. The fluid stream 134, which carries the second material 136, will have a

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low initial velocity when compared to the fluid streams 126 and 128 which carry the meltblown fibers. However, by adjusting the distance from the nozzle 144 to the impingement zone 130 (and the distances that the meltblown fiber gas streams 126 and 128 must travel), the velocity of the fluid stream 134 can be controlled to be greater than the meltblown fiber fluid streams 126 and 128 at the impingement zone.

Due to the fact that the multicomponent thermoplastic polymer fibers 120 are usually still semi-molten and tacky at the time of incorporation of the second material 136 into the multicomponent thermoplastic polymer filaments containing streams 126 and 128, the second material 136 is usually not only mechanically entangled within the matrix formed by the thermoplastic polymer fibers 120 but is also thermally bonded or joined to the multicomponent thermoplastic polymer fibers 120.

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In order to convert the composite stream 150 of multicomponent thermoplastic polymer fibers 120 and the second material 136 into a composite nonwoven structure 154 composed of a coherent matrix of the multicomponent thermoplastic polymer fibers 120 having the second material 136 distributed therein, a collecting device is located in the path of the composite stream 150. The collecting device may be an endless belt 158 conventionally driven by rollers 160 and which is rotating as indicated by the arrow 162 in Fig. 3. Other collecting devices are well known to those of skill in the art and may be utilized in place of the endless belt 158. For example, a porous rotating drum arrangement could be utilized. The merged composite streams of multicomponent thermoplastic polymer filaments and the

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second material are collected as a coherent matrix on the surface of the endless belt 158 to form the composite nonwoven web 154. Vacuum boxes (not shown) assist in retention of the matrix on the surface of the belt 158. The vacuum may be set at about 1 to about 4 inches of water column. Generally, in practicing the process of the present invention, as the line speed of the collecting device (158) is increased, the frequency of the perturbation of the flow of fluid also needs to be increased.

The coform nonwoven web composite structure 154 is coherent and may be removed from the belt 158 as a self-supporting nonwoven material. Generally speaking, the composite structure has adequate strength and integrity to be used without any post-treatments such as pattern bonding, calendaring and the like. However, the structure can be further stabilized by thermally bonding or compressing the composite structure. For example, a pair of pinch rollers or pattern bonding rollers, which may or may not be heated, may be used to bond portions of the material. Although such treatment may improve the integrity of the nonwoven composite structure 154, it also tends to compress and densify the structure.

If necessary or desired, the web 154 is then transported to a through air bonding (TAB) unit 170 to partially or fully activate the web 154, by bringing the polymer component A of the multicomponent filaments to a liquid state where it can flow onto, or wet, the second material in the web. By the phrase "partially activated," it is meant that less than a majority of the A polymer component is melted. By the phrase "fully activated," it is meant that the majority of the A polymer component is melted. Care should be taken to minimize flow of the melted sheath polymer beyond

that needed to wet the absorbents, especially in the case of the meltblown bicomponent fibers, which are much finer than bicomponent spunbond fibers and therefore more susceptible to a liquification scenario where the polymer component A may separate from the core polymer component if held too long in the fully activated state. Desirably, the web is subjected to between about 160°F and about 300°F for a period of time between about 0.5 to about 20 seconds to achieve full activation of polymer component A of the multicomponent meltblown filaments. More preferably, the time period is between about 1 to about 10 seconds and most preferably about 4-7 seconds. However, the type of polymer and the oven temperature will govern the actual time needed to melt the A polymer component.

While the web 154 is partially or fully activated, it is then densified, such as by compression through a nip formed by two calender rolls 172. Densification is desirable in a preferred embodiment to between about 0.01 g/cc and 0.50 g/cc, and more desirably to between about 0.05 g/cc and 0.20 g/cc for use in some personal product applications. The calendar rolls 172 may, but need not, provide point bonding of the web and may be heated to maintain the full activation of the web during densification. Alternatively, the calendar rolls 172 may be cooled to provide a means for removing heat from the fully activated web in order to solidify the flow of polymer component A which has wetted around the second material, thereby creating hardened flow joints securing the absorbent material within the thermoplastic matrix of the web. Alternatively, the densified web 156 is fixed to form the hardened flow joints and prevent further bonding or collapse of the web by a

forced air cooling unit 174 pulling ambient air through the web, or the like. The stabilized and densified web 156 can then be collected on a winding roll 176 or the like for later use, or in the alternative, the stabilized and densified web can be further processed directly from the formation process.

5 While the embodiments of the invention described herein are presently considered preferred, various modifications and improvements can be made without departing from the spirit and scope of the invention. The scope of the invention is indicated by the appended claims, and all changes within the meaning and range of equivalents are intended to be embraced therein.

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